Claims

- 1 1. An apparatus for processing a sample using sonic energy, the apparatus comprising:
- a sonic energy source for emitting sonic energy;
- a holder for the sample, the sample movable relative to the emitted sonic energy; and
- a processor for controlling the sonic energy source and location of the sample according
- to a predetermined methodology, such that the sample is selectively exposed to sonic energy to
- 6 produce a desired result.
- 1 2. The apparatus of claim 1 further comprising a feedback system connected to the
- 2 processor for monitoring at least one condition to which the sample is subjected during
- 3 processing, such that the processor controls at least one of the sonic energy source and the
- 4 location of the sample in response to the at least one condition.
- 1 3. The apparatus of claim 1 wherein the desired result is selected from the group consisting
- of heating the sample, cooling the sample, fluidizing the sample, mixing the sample, stirring the
- sample, disrupting the sample, increasing permeability of a component of the sample, enhancing
- 4 a reaction within the sample, and sterilizing the sample.
- 1 4. The apparatus of claim 1 further comprising a temperature control unit for controlling
- 2 temperature of the sample.
- 1 5. The apparatus of claim 4 wherein the processor controls the temperature control unit.
- 1 6. The apparatus of claim 1 further comprising a pressure control unit for controlling
- 2 pressure to which the sample is exposed.
- The apparatus of claim 6 wherein the processor controls the pressure control unit.
- 1 8. The apparatus of claim 1 wherein the sonic energy source comprises a transducer.
- 1 9. The apparatus of claim 8 wherein the transducer focuses the sonic energy.
- 1 10. The apparatus of claim 8 wherein the transducer is selected from the group consisting of
- at least one piezoelectric element, an array of piezoelectric elements, an electrohydraulic
- 3 element, a magnetostrictive element, an electromagnetic transducer, a chemical explosive
- 4 element, a laser-activated element, and combinations thereof.
- 1 11. The apparatus of claim 10 wherein the at least one piezoelectric element includes a
- 2 spherical transmitting surface oriented such that the focal axis is vertical.
- 1 12. The apparatus of claim 1 wherein the holder supports a sample container for containing
- 2 the sample.
- 1 13. The apparatus of claim 12 wherein the sample container is selected from the group
- 2 consisting of a membrane pouch, a thermopolymer well, a polymeric pouch, a hydrophobic

- membrane, a microtiter plate, a microtiter well, a test tube, a centrifuge tube, a microfuge tube,
- an ampoule, a capsule, a bottle, a beaker, a flask, and a capillary tube.
- 1 14. The apparatus of claim 12 wherein the sample container forms multiple compartments.
- 1 15. The apparatus of claim 12 wherein the sample container includes a rupturable membrane
- 2 for transferring a fraction of the sample away from the holder.
- 1 16. The apparatus of claim 1 further comprising a device for moving the sample from a first
- 2 location to a second location.
- 1 17. The apparatus of claim 16 wherein the device for moving the sample comprises a stepper
- 2 motor.
- 1 18. The apparatus of claim 2 wherein the feedback system comprises a sensor for monitoring
- 2 the at least one condition.
- 1 19. The apparatus of claim 1 further comprising an acoustically transparent material disposed
- 2 between the sonic energy source and the holder.
- 1 20. The apparatus of claim 1 wherein the desired result comprises an in vitro treatment.
- 1 21. The apparatus of claim 1 wherein the desired result comprises an ex vivo treatment.
- 1 22. The apparatus of claim 1 wherein the sample flows through a conduit.
- 1 23. The apparatus of claim 1 wherein the sonic energy source generates sonic energy at two
- 2 different frequencies.
- 1 24. The apparatus of claim 1 wherein sonic energy source generates a wavetrain.
- 1 25. The apparatus of claim 24 wherein the wavetrain comprises a first wave and a different
- 2 second wave.
- 1 26. The apparatus of claim 24 wherein the wavetrain comprises about 1000 cycles per burst
- at about a 10% duty cycle at about 500 mV.
- 1 27. A method for processing a sample with sonic energy, the method comprising the steps of:
- 2 exposing the sample to sonic energy; and
- controlling at least one of the sonic energy and location of the sample relative to the sonic
- 4 energy according to a predetermined methodology, such that the sample is selectively exposed to
- sonic energy to produce a desired result.
- 1 28. The method of claim 27 further comprising the steps of sensing at least one condition to
- which the sample is subjected during processing and altering at least one of the sonic energy and
- the location of the sample in response to the at least one condition.

- 1 29. The method of claim 28 wherein during the sensing step, the at least one condition is
- 2 selected from the group consisting of temperature, pressure, an optical property, an altered
- 3 chemical, an acoustic signal, and a mechanical occurrence.
- 1 30. The method of claim 28 wherein during the altering step, at least one characteristic of the
- 2 sonic energy is altered, the at least one characteristic selected from the group consisting of wave
- form, duration of application, intensity, and duty cycle.
- 1 31. The method of claim 27 wherein the desired result is selected from the group consisting
- of heating the sample, cooling the sample, fluidizing the sample, mixing the sample, stirring the
- 3 sample, disrupting the sample, increasing permeability of a component of the sample, enhancing
- 4 a reaction within the sample sterilizing the sample, and combinations thereof.
- 1 32. The method of claim 27 further comprising the step of controlling temperature of the
- 2 sample.
- 1 33. The method of claim 27 further comprising the step of controlling pressure to which the
- 2 sample is exposed.
- 1 34. The method of claim 27 wherein during the step of exposing the sample to sonic energy,
- 2 the sonic energy is generated by at least one process selected from the group consisting of spark
- discharges across a gap, laser pulses, piezoelectric pulses, electromagnetic shock waves,
- 4 electrohydraulic shock waves, electrical discharges into a liquid, and chemical explosives.
- 1 35. The method of claim 27 wherein the sonic energy is focused on the sample.
- 1 36. The method of claim 27 wherein the sample contains a cell, the method further
- 2 comprising the step of introducing a material into the cell.
- 1 37. The method of claim 36 wherein the material is selected from the group consisting of a
- 2 polymer, an amino acid monomer, an amino acid chain, a protein, an enzyme, a nucleic acid
 - monomer, a nucleic acid chain, a saccharide, a polysaccharide, an organic molecule, an inorganic
 - 4 molecule, a vector, a plasmid, a virus, and combinations thereof.
 - 1 38. The method of claim 27 further comprising the step of extracting a component of the
 - 2 sample.
 - 1 39. The method of claim 27 wherein during the controlling step, at least one characteristic of
 - 2 the sonic energy is controlled, the at least one characteristic selected from the group consisting of
 - wave form, duration of application, intensity, and duty cycle.
 - 1 40. The method of claim 27 wherein the desired result comprises an in vitro treatment.
 - 1 41. The method of claim 27 wherein the desired result comprises an ex vivo treatment.

- 1 42. The method of claim 27 further comprising the step of the sample flowing through a
- 2 conduit.
- 1 43. The method of claim 27 wherein the sonic energy comprises at least two different
- 2 frequencies.
- 1 44. The method of claim 27 wherein sonic energy source comprises a wavetrain.
- 1 45. The method of claim 44 wherein the wavetrain comprises a first wave and a different
- 2 second wave.
- 1 46. The method of claim 44 wherein the wavetrain comprises about 1000 cycles per burst at
- about a 10% duty cycle at about 500 mV.